

The secret mechanics of soft gels

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Scientific context Gels constitute a large portion of the materials around us: body tissues, food products, but also industrial glues and seals. At first glance, they are mechanically similar to other elastic materials. If you take a piece of gelatin, for instance, you can deform it by a small amount and it will return to its original shape. If you look closer, however, gels have a complex molecular structure. They are made of a crosslinked polymeric network swollen by a liquid solvent (Fig. 1A). As a consequence, their mechanical behavior is dictated by the coupling between the elastic deformations of the polymeric network and the flow of the solvent. For simplicity, they are often modeled as incompressible solids, and these models are then used to estimate, for instance, adhesion forces of cells living on soft tissues [1] (Fig. 1B). Whether they truly behave as incompressible solids, however, is both difficult to assess and crucial for an accurate modeling.

Missions In this project, we will take a deep dive into gel mechanics. You will exploit recently collected experimental data, which tracks the 3D displacement of the polymeric network inside a silicone gel (Fig. 1C), to understand in which circumstances a gel can be modeled as an incompressible solid. This will involve numerically analyzing the displacement of tens of thousands of tracers, and rationalizing the results within the framework of continuum mechanics. The results will be directly compared with existing numerical predictions [2].

Outlooks You will be using state of the art numerical analysis tools, and will be free to publish your version as an open coding package. The opportunity to continue as a Ph.D. student could also be considered.

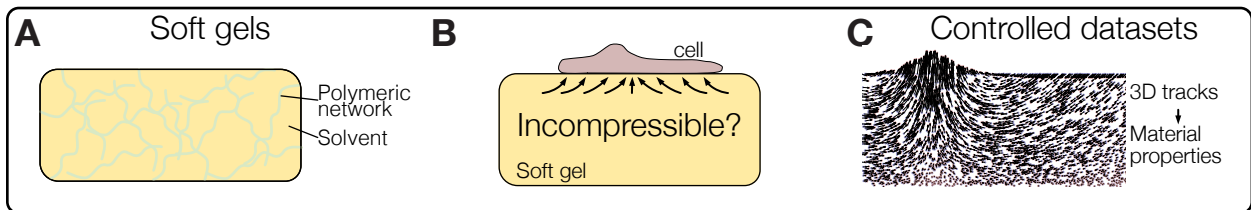


Figure 1: Project overview (A) Gels have a complex molecular structure. (B) Knowing their mechanical properties is essential to measure forces exerted by living cells. (C) We will study the material properties by using 3D tracks in a controlled dataset on soft silicone gels.

Bibliography

- [1] H. Delanoë-Ayari and A. Nicolas. *Phys. Rev. E* (2 2022). | [2] M. M. Flapper et al. *Phys. Rev. Lett.* (22 2023).